Adapting the SBND warm interface to ProtoDUNE

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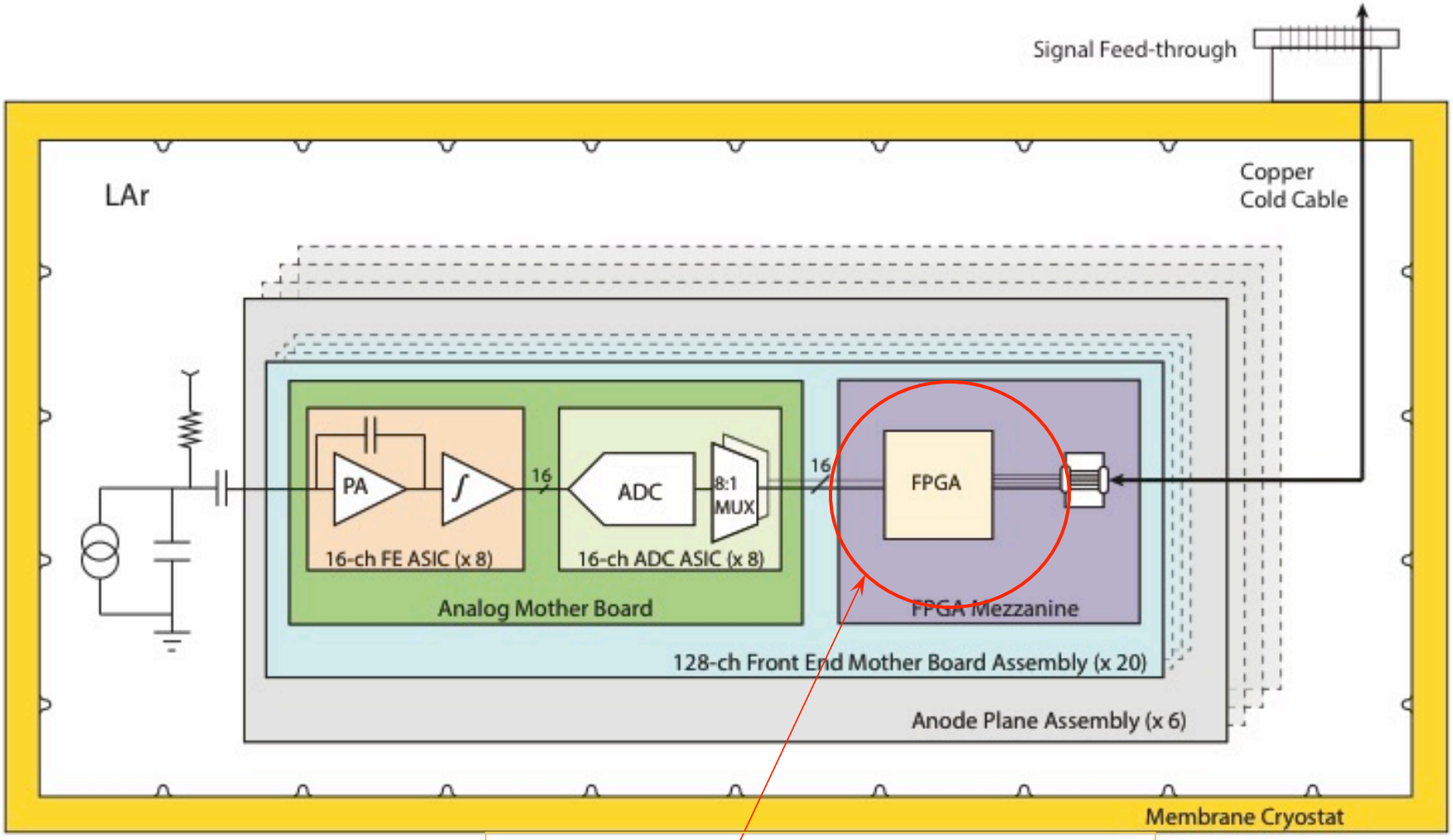
Outline

- TPC Cold Electronics
- SBND & ProtoDUNE FEMB
- SBND Warm Interface electronics
- Proposed ProtoDUNE Warm Interface Electronics
  - Warm Interface Board (WIB)
  - Power & Timing Backplane (PTB)
  - Power & Timing Card (PTC)
  - ProtoDUNE Warm Electronics Crate
- Summary

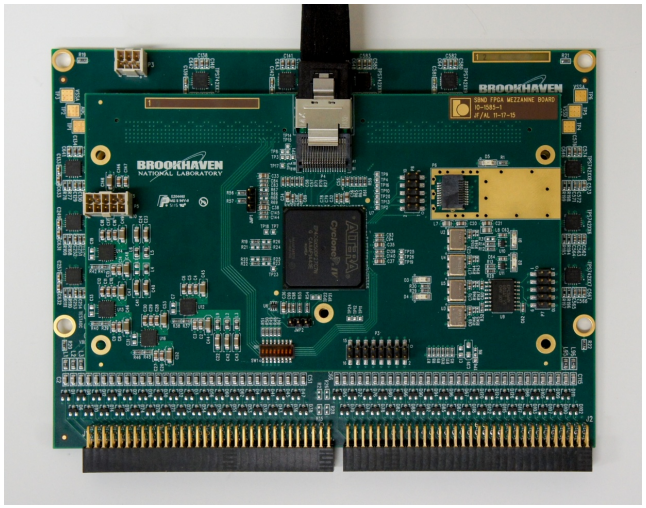
ProtoDUNE TPC Cold Electronics



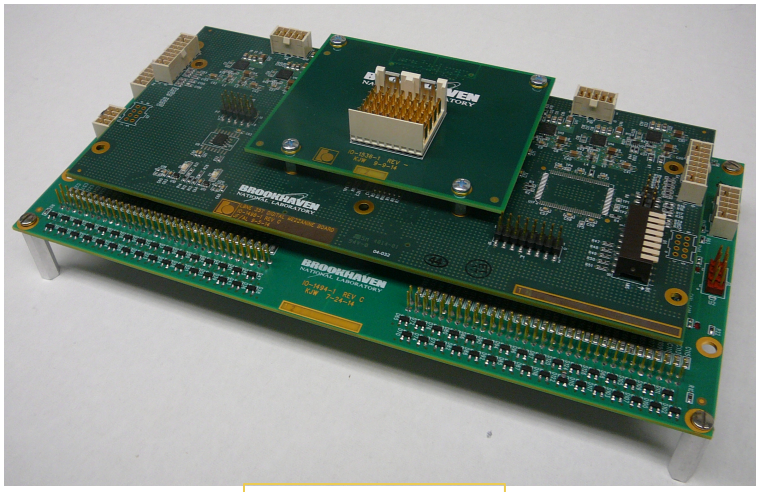
Cold FPGA in ProtoDUNE & SBND

SBND & ProtoDUNE FEMB

- SBND & ProtoDUNE FEMB's are functionally identical
  - Will most likely have the same firmware to mimic "COLDDATA"
- Board layout differences between the FEMB's
  - Power and data connectors are different due to cable length to the feed through flange
    - SBND 7 meters
    - ProtoDUNE 18 – 25 meters
  - ProtoDUNE and SBND have different APA's – connectors & wire pitch

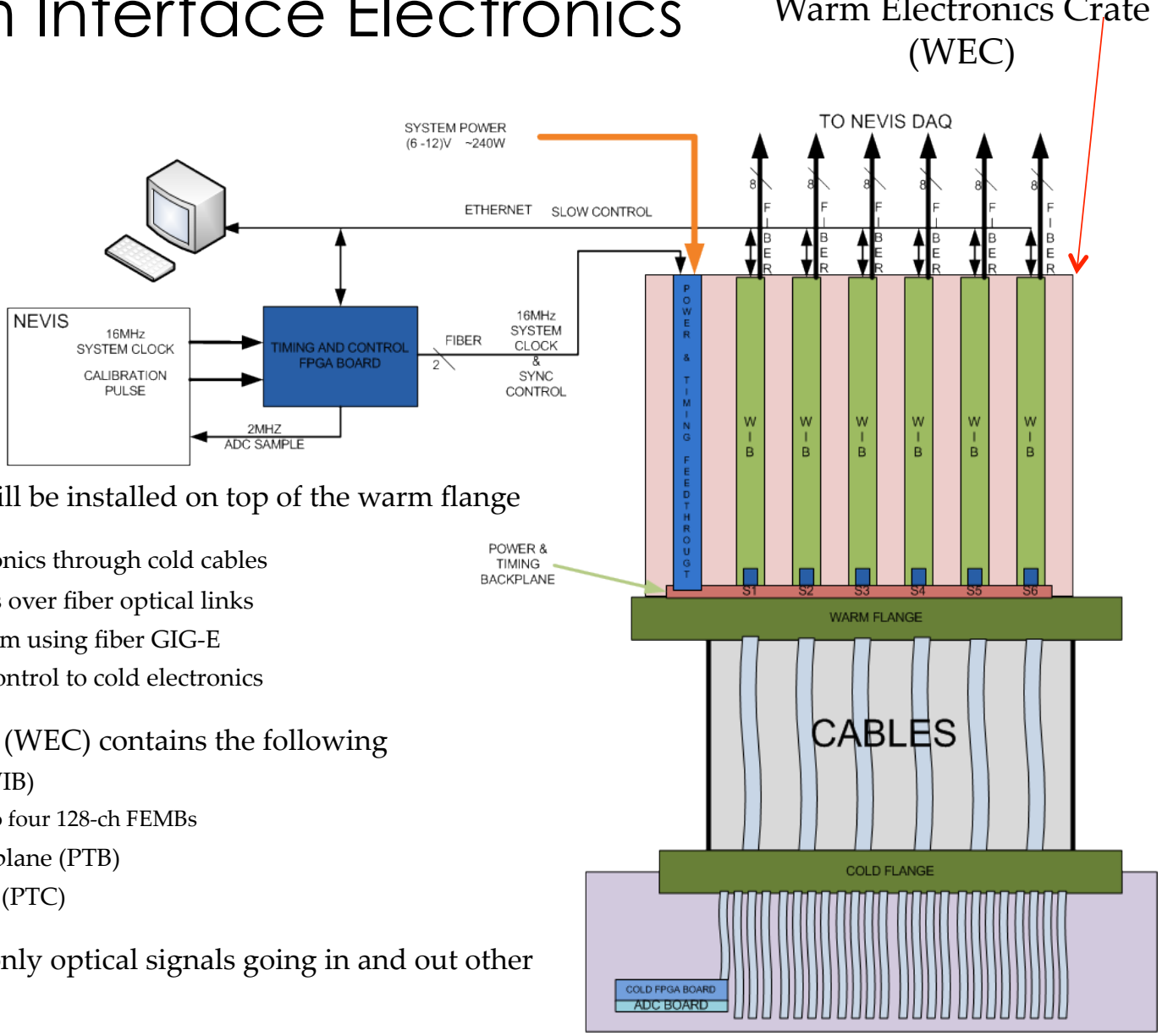


SBND FEMB



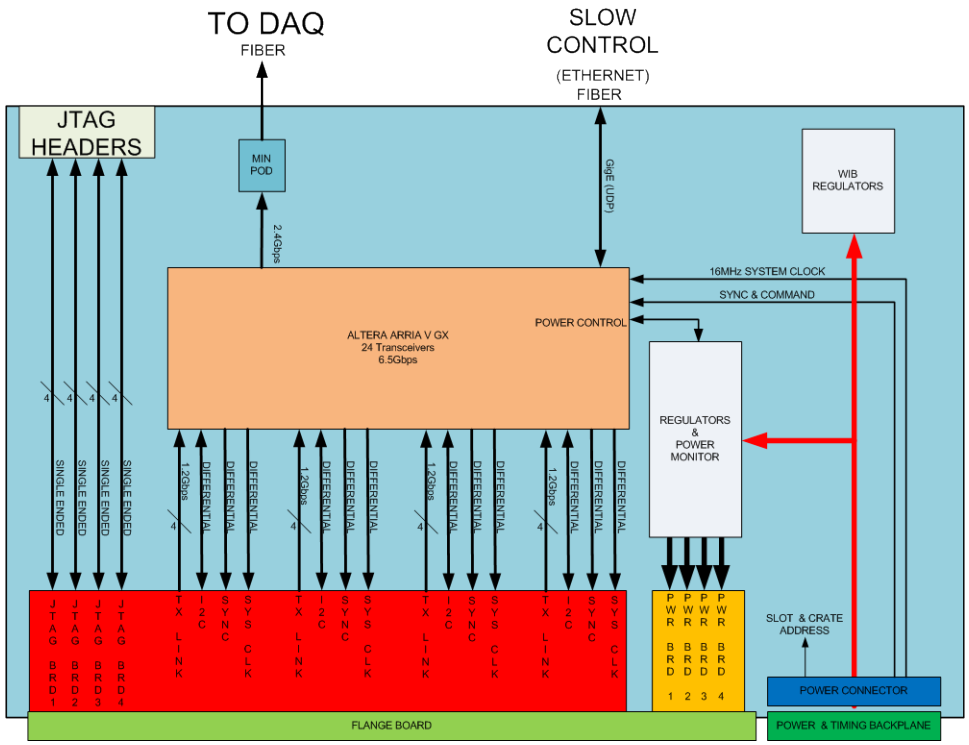
35T FEMB

SBND Warm Interface Electronics

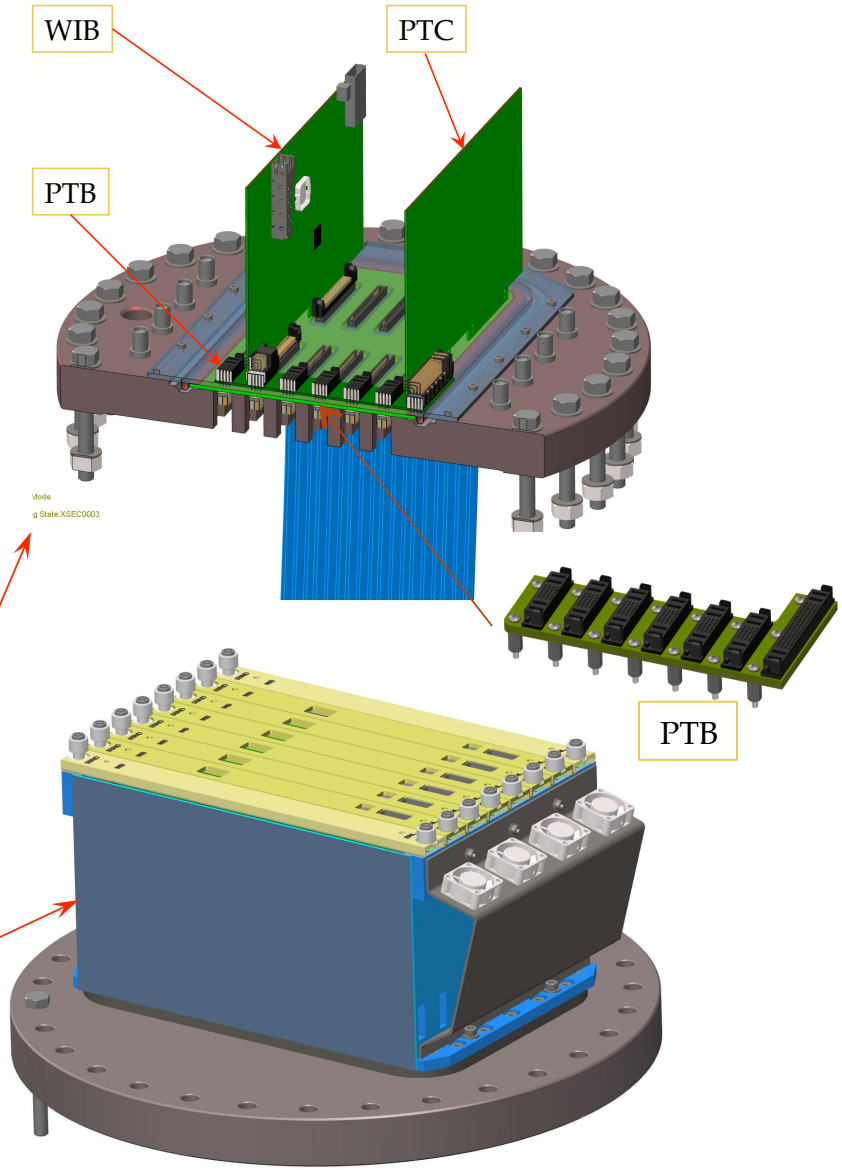


- Warm interface electronics will be installed on top of the warm flange board
  - Receive data from cold electronics through cold cables
  - Send data to Nevis electronics over fiber optical links
  - Interface to slow control system using fiber GIG-E
  - Manage power, timing and control to cold electronics
- Each Warm Electronics Crate (WEC) contains the following
  - Six Warm Interface Boards (WIB)
    - Each WIB will control up to four 128-ch FEMBs
  - One Power and Timing back plane (PTB)
  - One Power and Timing Card (PTC)
- WEC is a faraday cage with only optical signals going in and out other than the main power
- Total up to 3072 channels per WEC, SBND uses 2816 channels

SBND Warm Interface Electronics



Warm Interface Board

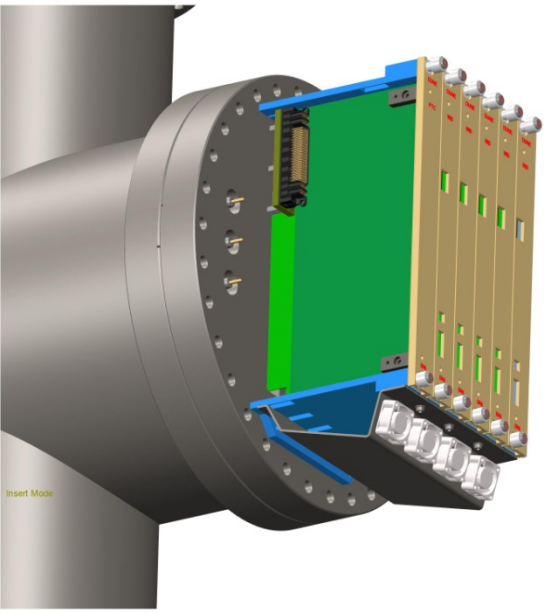


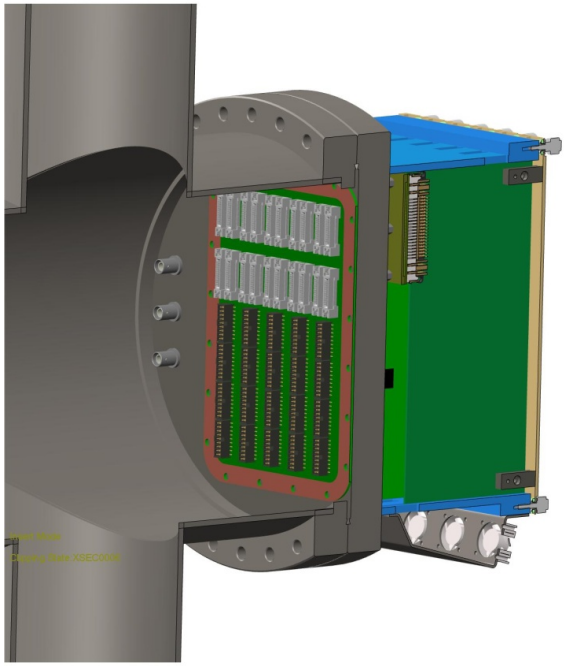
Warm Interface Electronics in Faraday crate on Signal Feed-through

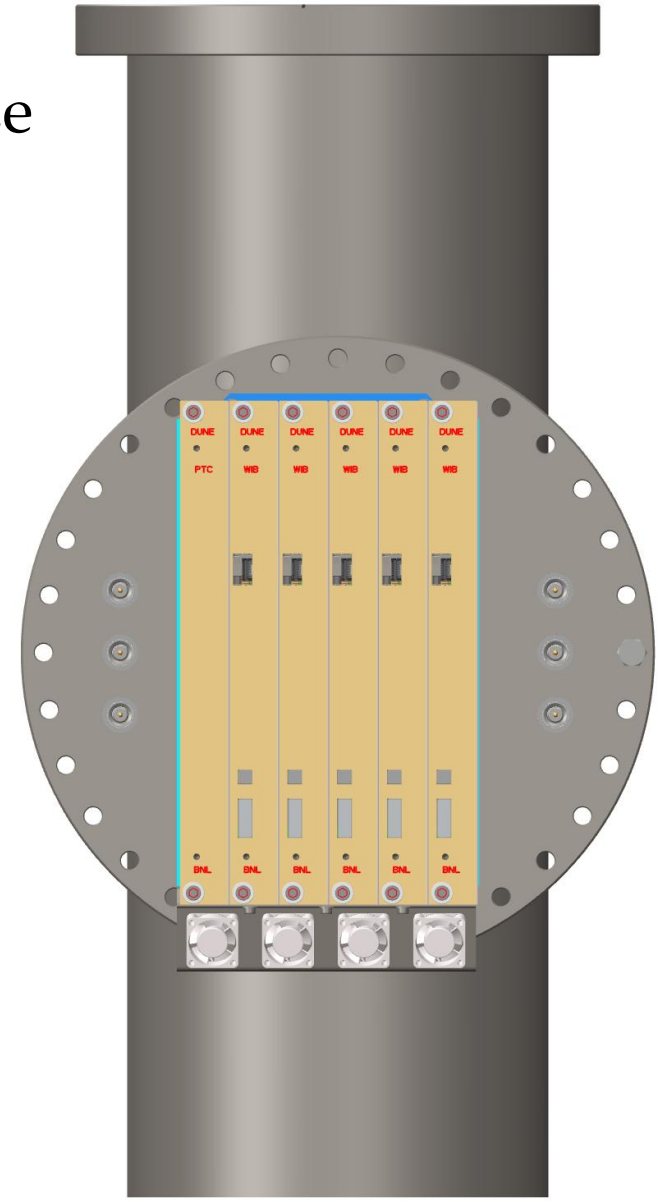
- SBND warm interface electronics can be easily adapted to protoDUNE

ProtoDUNE Warm Interface Electronics

- The 12 inch flange will reduced the size of the Warm Electronics Crate so that only five WIB's will be used per flange
  - SBND has a 14" flange with 6 WIB's

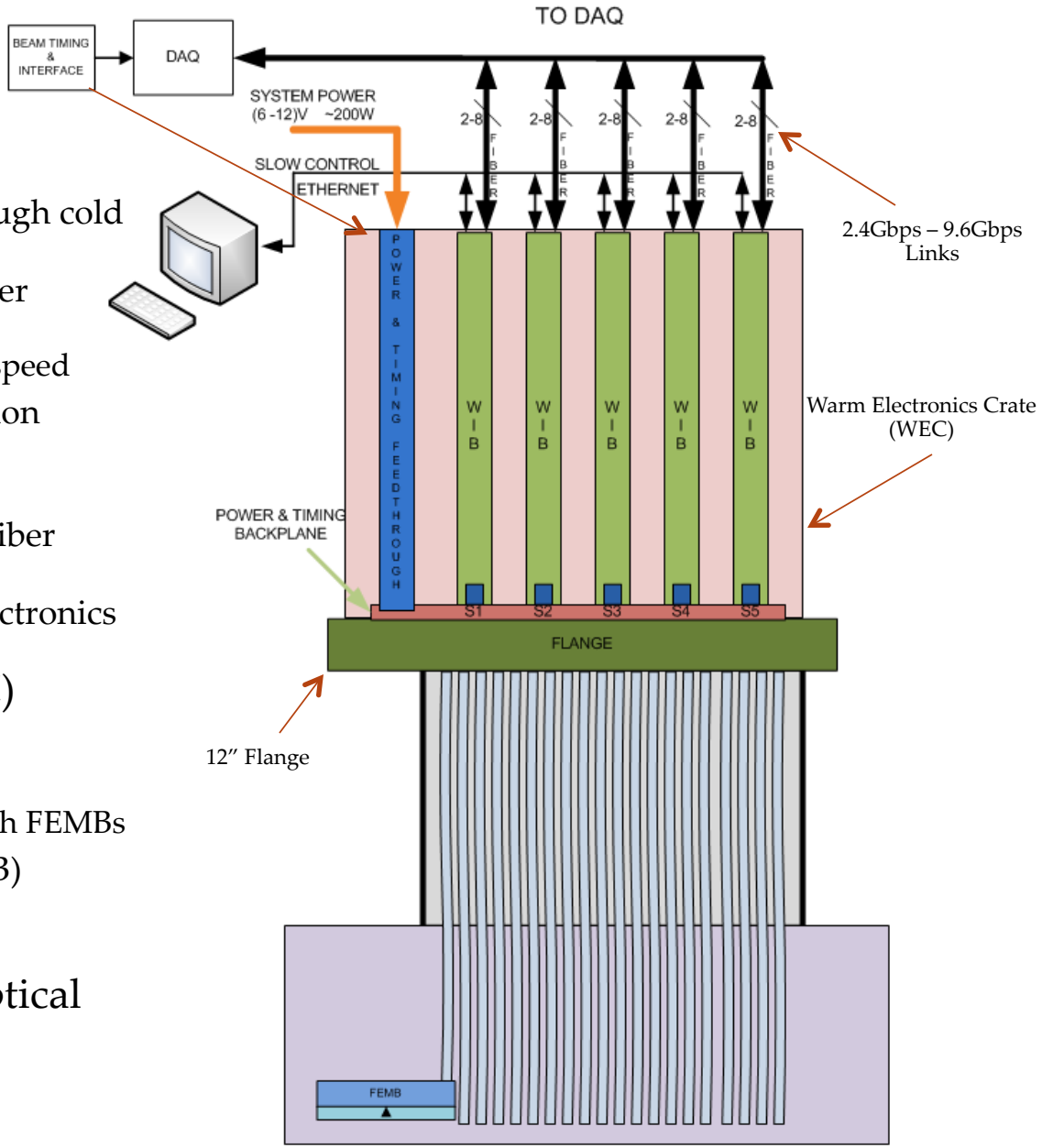






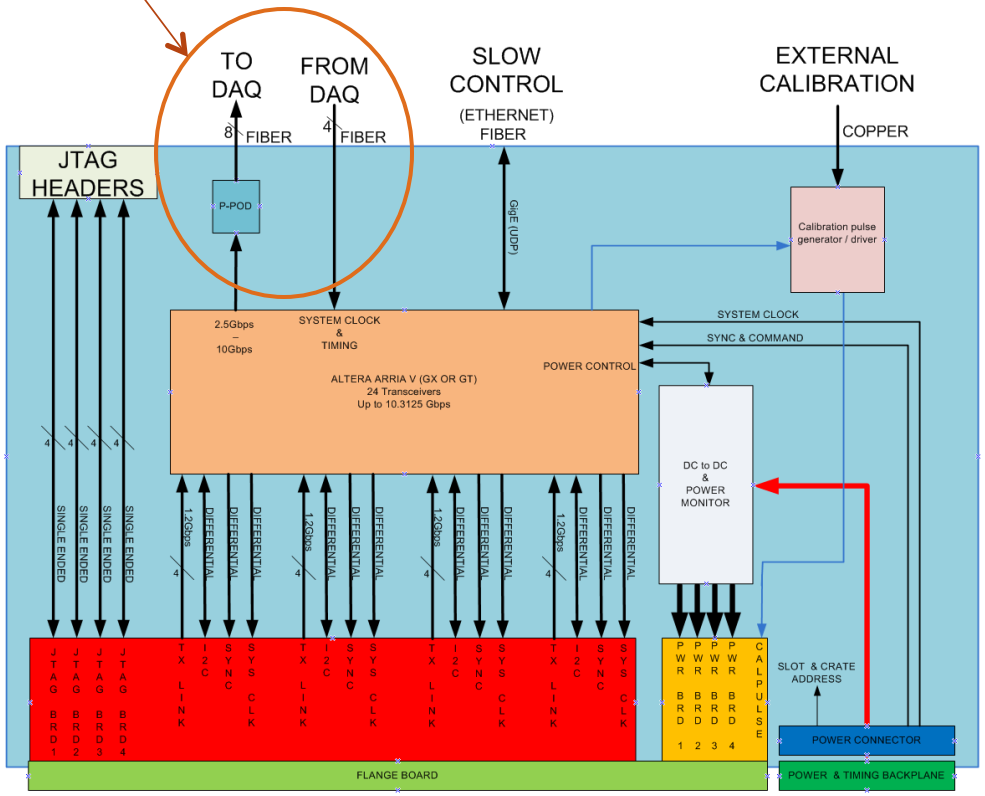
Proposed ProtoDUNE Warm Interface Electronics

- Warm interface electronics will be installed flange board
  - Receive data from cold electronics through cold cables
  - Send data to ProtoDUNE DAQ over fiber optical links
    - Two to eight links depending on link speed
  - Receive system clock and synchronization signals form DAQ over fiber links
    - (PTC or WIB)
  - Interface to slow control system using fiber GIG-E
  - Manage power and control for cold electronics
- Each Warm Electronics Crate (WEC) contains the following
  - Five Warm Interface Boards (WIB)
    - Each WIB will control up to four 128-ch FEMBs
  - One Power and Timing back plane (PTB)
  - One Power and Timing Card (PTC)
- WEC is a faraday cage with only optical signals going in and out



Proposed ProtoDUNE Warm Interface Board

- Replace Altera Arria V FPGA with GT variant for higher link speeds (10Gb/s)
  - No layout change needed.
- PPOD can be replaced to QSFP socket
  - A minimal layout change will be required.



Used by WIB

Variant	Member Code	Package F672	F780	F896	F 1152	F1517
Arria V GX	A1					
	A3					
	A5					
	A7					
	B1					
	B3					
	B5					
	B7					
Arria V GT	C3					
	C7					
	D3					
	D7					
Arria V GZ	E1					
	E3					
	E5					
	E7					
Arria V SX	B3					
	B5					
Arria V ST	D3					
	D5					

Arria V FPGA migration table

Warm Interface Board (WIB)

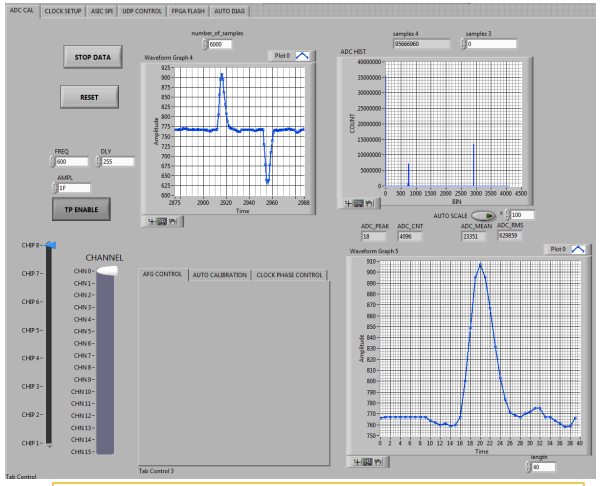
- The WIB can control up to 4 cold FPGA boards, signals for each FEMB include
  - Four 1.20Gbps receiver links
  - One set of differential I2C* links
  - One differential system clock
  - One differential SYNC/CONTROL link
  - One set of FPGA JTAG signals (single ended)
    - FPGA can be reprogrammed for two pairs of differential signals
- Can send data to the DAQ over high speed links with speeds ranging from 2.4Gbps to 10.3125 Gbps
- Can receive up to two high speed serial links and two clock links from DAQ
  - This can serve as communication channels to control system
- Communicates to the control system through a Gigabit Ethernet link using UDP
  - This will be used as the diagnostic tool

Warm Interface Board (WIB)

- Communicate to slow control system with an Gigabit Ethernet link using UDP
  - IP address is generated by slot and crate address
  - The WIB behaves as a slave only responding to a online monitoring master*.
- Built in calibration pulse generator which can be triggered by the sync/ control link or from slow control
  - Each FEMB has can be controlled independently
  - External calibration can be accomplished by a connector the on front panel of the WIB or slow control
  - **Calibration pulse distribution is for risk mitigation only**
- On board flash memory can be used to store multiple default settings for WIB and FEMBs that can be loaded at power up
- The WIB has onboard DC/DC converters used to power the FEMBs.
  - There are 5 DC/DC converters for each FEMB and can deliver up to 4A per line
  - Each DC/DC converter has voltage and current monitoring
  - Each DC/DC converter can be individually enabled or disabled through slow control
  - The WIB can control each DC/DC switching frequency & phase

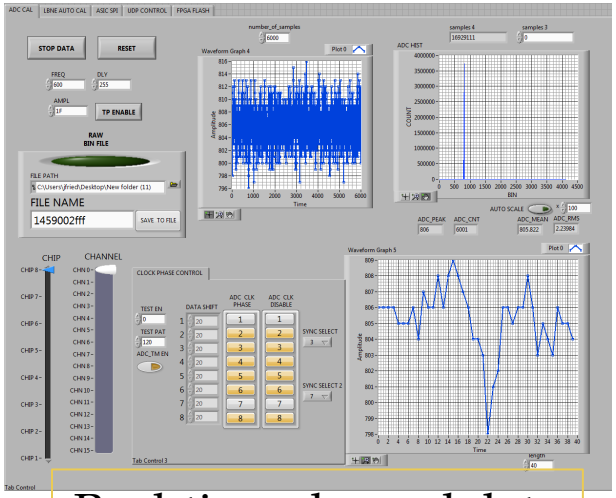
Warm Interface Board (WIB)
Slow Control / Debugging Features

- Monitors and control FEMB voltages and currents
  - Can set alert triggers to be sent to online monitoring
- Monitors FEMB ASIC status over high speed link
  - Can set alert triggers to be sent to online monitoring
- Read and write FEMB registers
- Read and write FEMB ASIC SPI chains
- Program and verify FEMB FPGA flash memory
- Store default settings on the on-board flash device
- Can select to use on-board or system clock
- Can Peek at high speed data link in real time over slow control
  - Can only monitor one ASICs worth of data at a time (16 channels)
- Can generate mock CE data to be sent to DAQ
- **Utilize all engineering development tools used at BNL for testing FEMB's**
  - Can plug a laptop containing BNL tools into the Ethernet switch or directly into a WIB
  - Can be used simultaneously with DAQ system
  - Will simplify debugging of entire system

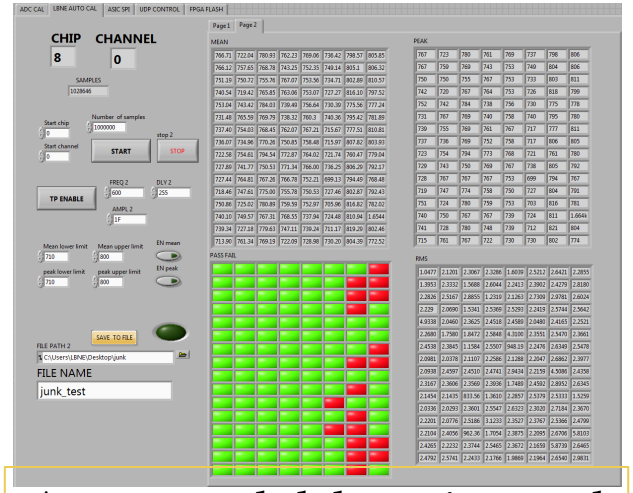


Real-time channel data

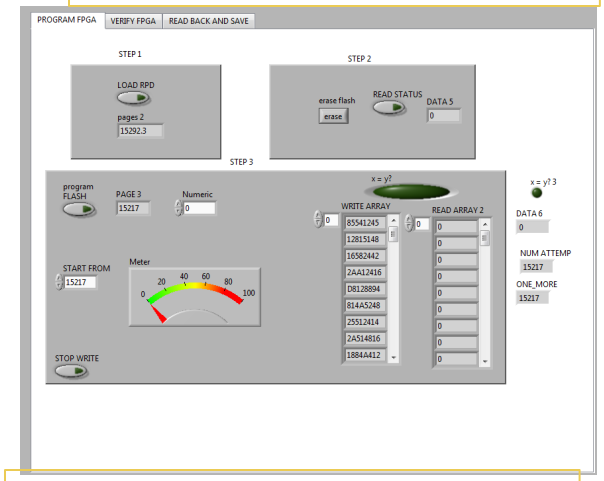
SBND Development tools



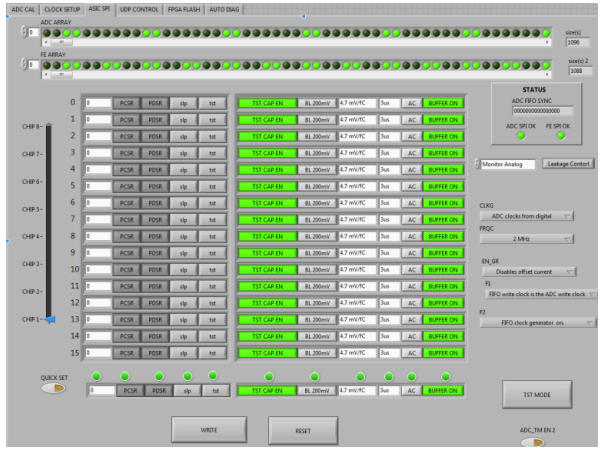
Real-time channel data



Automated debugging tool



FPGA programming tool

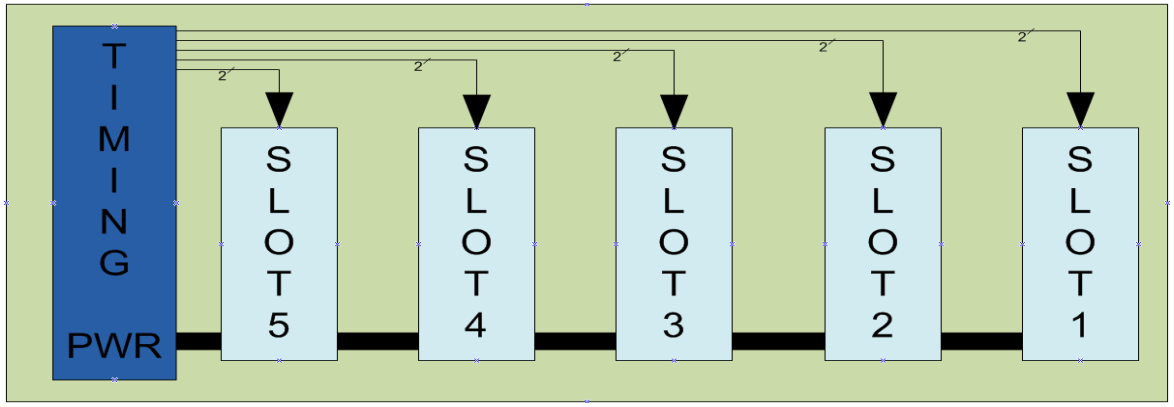


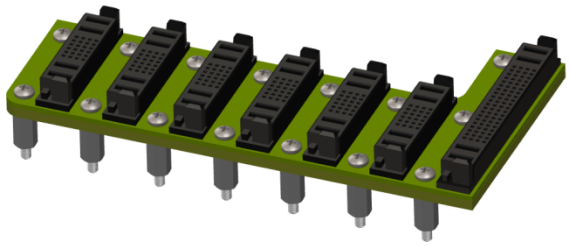
ASIC SPI Programming

Power & Timing Backplane (PTB)

- Passive Backplane
- Power distribution for 5 warm interface boards (WIB)
- Can distributes system clock and sync/control signals to each WIB
  - Each signal is a point to point connection and is individually terminated on the WIB
- Each slot has a unique slot address and a global crate address
  - Crate address is selected on the Power & timing Card (PTC)
  - Used to generate GIG-E IP address on WIB
- Power and timing card slot
- Minimum layout Change is required from SBND version

PTB

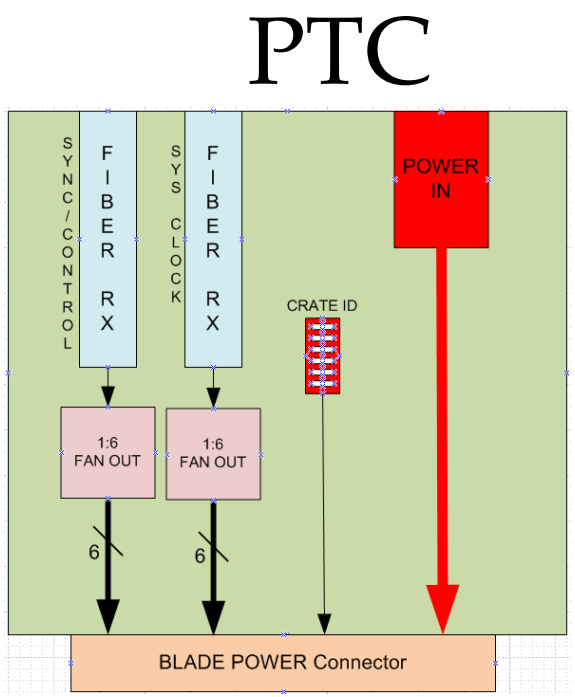




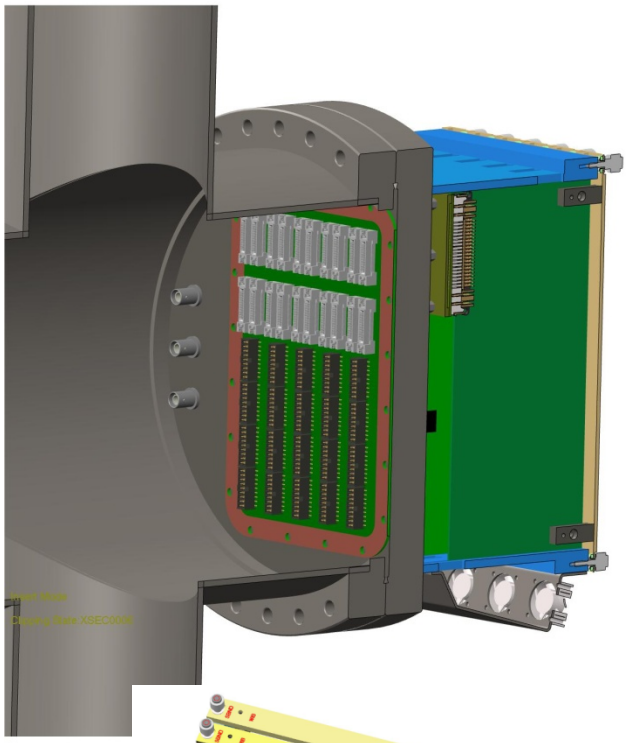
SBND PTB

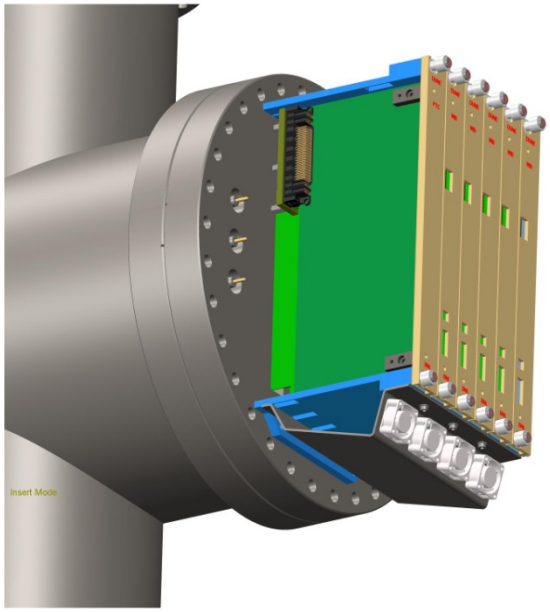
Power & Timing Card (PTC)

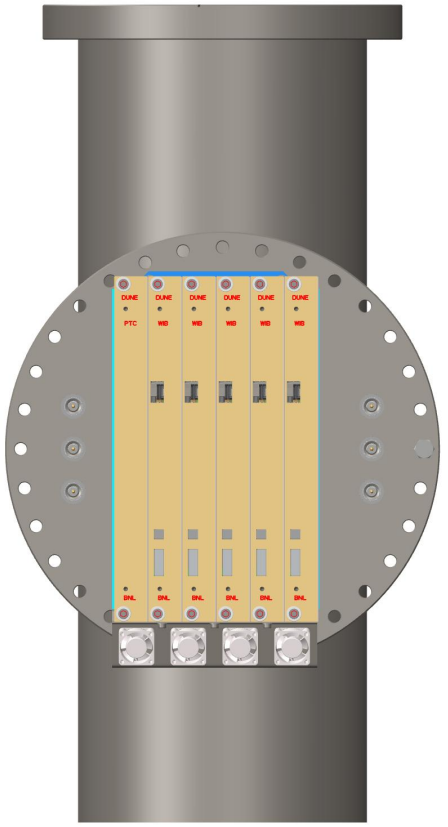
- The PTC allows for power and control signals to be brought to the Warm Electronics Crate in a clean and efficient manor
- Warm Electronics Crate power input
  - 12V ~200W
- Two fiber optic receivers can be used for system clock and sync/control
  - A 1:5 fan out of the signals to each WIB
- A dip switch allows for selection of a crate address which is bused to each WIB (used for IP address generation)
- No layout change is required from SBND version

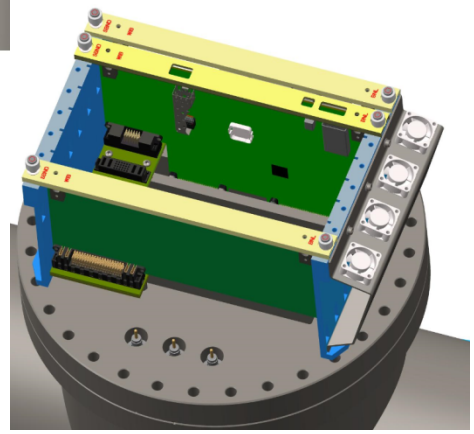


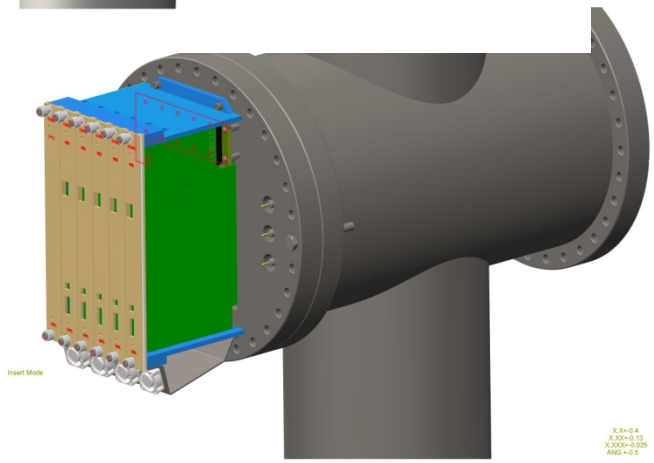
ProtoDUNE Warm Electronics Crate









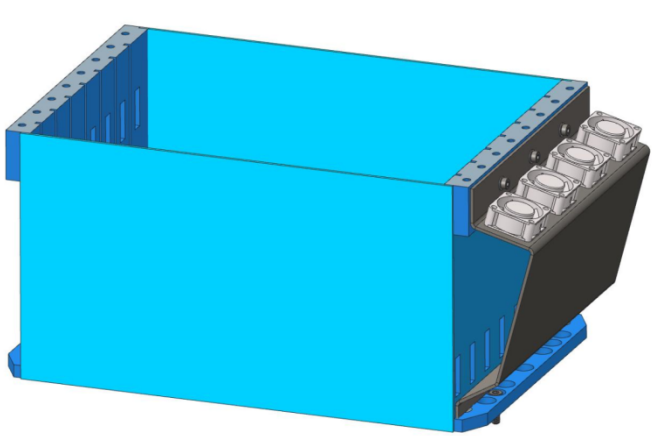


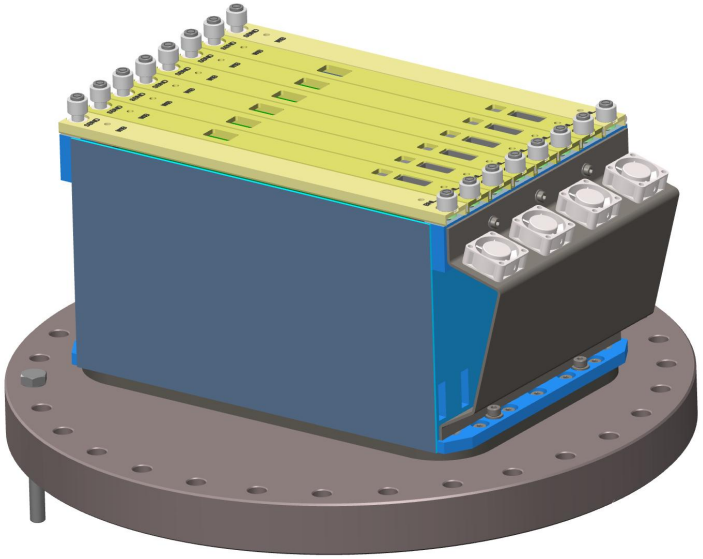
Summary

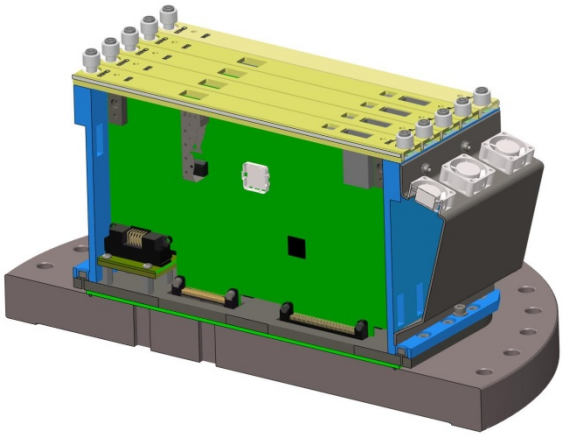
- **SBND warm interface electronics can be easily adapted to protoDUNE**
- Schematic design of warm interface electronics is finished, including WIB, PTB, PTC
- Layout design of WIB is ongoing
- Warm electronics crate (WEC) design has started
- Plan to have the first SBND test stand built by Spring 2016, when prototype TPC FE electronics become available

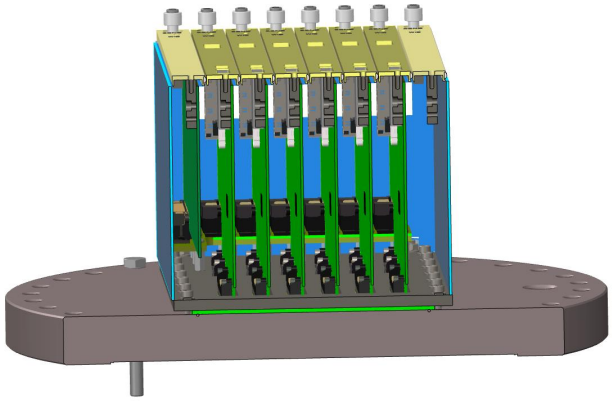
Backup Slides

SBND Warm Electronics Crate

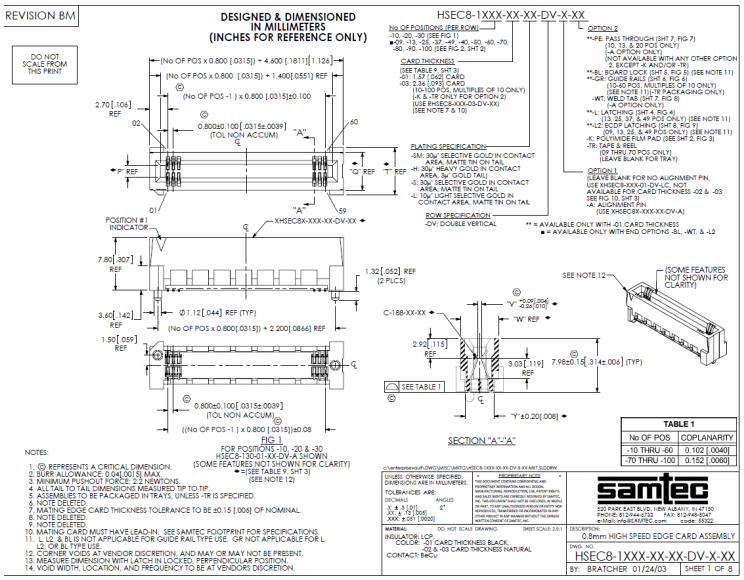


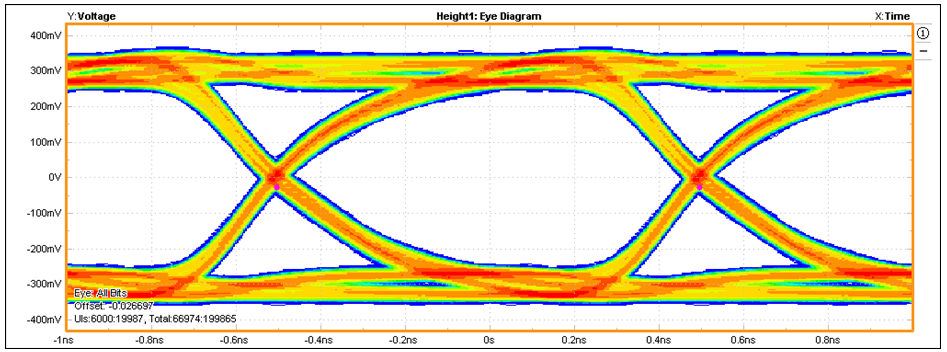


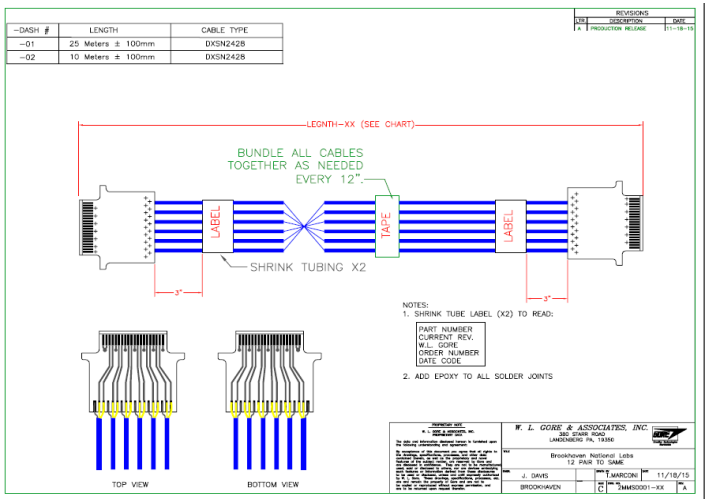


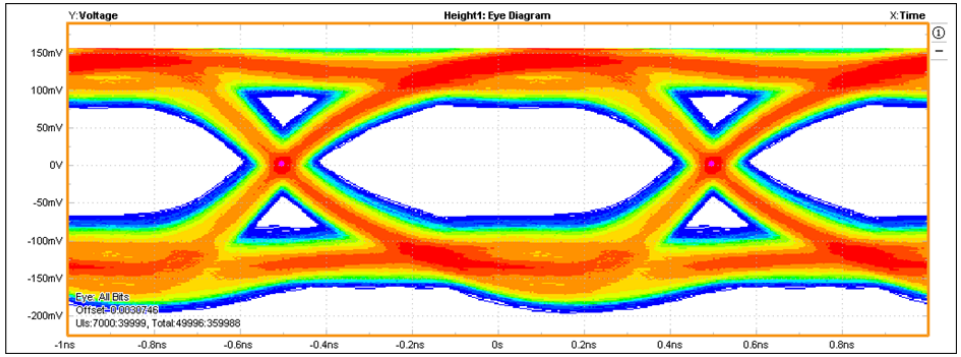


DUNE GORE COLD CABLE









WIB FPGA
Migration for Arria V Devices